RESERVE C

PATENT SPECIFICATION

723,541

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COMPLETE SPECIFICATION

Pressure Gauge particularly for Indicating the Amount of Volatile Liquid in a Container

We, BENDIX AVIATION CORPORATION, a Corporation of the State of Delaware, United States of America, of 401, Bendix Drive, South Bend, Indiana, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an improved pressure-gauge of the differential type and to the utilisation of such a gauge in a device for indicating the quantity of volatile liquid contained in an insulated vessel.

According therefore, to the present invention there is provided a differential pressure-gauge, which comprises a diaphragm mounted in a sealed casing connectable on opposite sides of the diaphragm to sources of different pressure, indicating means in said casing including a dial and an indicator movable with respect to the dial, a mechanical connection from the diaphragm to the indicator to move the latter on deflection of the diaphragm in response to variations in said pressure difference, spring means tending to support the diaphragm in a null position relatively to the casing, and further spring means biassing the diaphragm in one direction only towards its said null position.

According also to a further aspect of the invention there is provided a liquid contents gauge adapted for use with a vessel containing a volatile liquid and having pressure conduits for sensing a pressure differential resulting from the quantity of liquid in the vessel, which gauge comprises a diaphragm mounted in a sealed casing connectable on opposite sides of the diaphragm to said respective conduits, indicating means in said casing including a dial calibrated to indicate the quantity of liquid in the vessel and an indicator movable with respect to the dial, a mechanical connection from the diaphragm to the indicator to move the latter on deflection of the diaphragm in response to variations in said pressure differential, spring means tending to support the diaphragm in a null position relatively to the casing, and further spring means biassing the diaphragm in one direction only towards its said null position.

The invention will now be described by way of example with reference to the accompanying drawings in which:—

Fig. 1 is a schematic view partially in section showing a flask containing a volatile liquid having the present invention associated therewith;

Fig. 2 is a longitudinal section taken along a diameter of the gauge casing, showing the mechanism of the gauge in elevation and the relative positions of the elements of the mechanism when the gauge is in zero or null position; and

Fig. 3 is a fragmentary view of the mechanism looking to the right of the mechanism as shown in Fig. 2;

Fig. 4 is a curve indicating the ratio between hydrostatic pressure expressed in terms of inches of water pressure and quantity expressed in terms of volume of a volatile liquid contained within a flask having a spherical internal configuration as shown in Fig. 1.

Volatile liquids such as liquid air, oxygen or nitrogen are usually contained within insulated flasks in order to prevent, as far as possible, the vaporisation of the liquid into a gas. Since volatile liquids vaporise almost instantaneously upon being withdrawn from the insulated flask, it is apparent that when an uninsulated conduit or tube is connected to the bottom of a flask, the volatile liquid entering such a conduit will vaporise instantaneously into a gas. Moreover, the pressure exerted upon the gas formed in the conduit will be the sum of the pressure in the flask existing above the level of the liquid and the hydrostatic pressure or head of the liquid above the conduit. On the other hand, a

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conduit associated with the top portion of the flask, will receive gas evaporated from the exposed surface of the liquid in the flask, but the pressure exerted on the gas in the top conduit will be equal only to the pressure existing in the flask above the liquid level. It is apparent, therefore, that a pressure differential equal to the head or hydrostatic pressure of the liquid within the flask exists between the pressures within the top and bottom conduits. Moreover, as the liquid level varies either due to the addition of more liquid or to the withdrawal of liquid from the flask, the pressure differential will vary as a function of the quantity of the liquid within the flask.

To utilise the pressure differential above set forth to indicate the quantity of liquid within the flask, the top conduit is placed in communication with one side of the diaphragm of a pressure responsive gauge while the bottom conduit is placed in communication with the opposite side of the diaphragm. The deflections of the diaphragm from a null or zero position, where there is no liquid within the flask, reflect the varying pressure differentials existing in the conduits and through suitable linkage and gear mechanism may be used to move an indicator arm over a scale calibrated to indicate the quantity of liquid within the flask.

Referring now to the drawings for a more detailed description of the present invention, Fig. 1 shows a flask 10 having an insulated wall 11 and a cap 12 closing the top of the flask 10. A volatile liquid 13 such as liquid oxygen, for example, partially fills the interior of the flask 10. It is apparent that the space 14 defined by the interior of the flask 10 above the upper surface or level 15 of the liquid 13 will be filled with gaseous oxygen due to the evaporation of the liquid oxygen 13.

In order to provide means whereby the pressure of the gas in the space 14 may be balanced with the ambient atmospheric pressure, or maintained under a pressure in excess of the ambient atmospheric pressure, the cap 12 is provided with a vent or check valve 16. Thus, if it is desired to maintain the pressure of the gas in space 14 at atmospheric pressure the valve 16 is adjusted to permit the former to balance with the latter. On the other hand, if a positive pressure relative to ambient atmospheric pressure is desired within the space 14, a pressure source may be associated with the flask 10 and the valve 16 adjusted to maintain the pressure supplied from said source. It is to be noted, however, that regardless of whether the gas in space 14 is maintained at atmospheric pressure or at a positive pressure relative thereto, the invention will function to indicate the quantity or liquid level of the liquid 13 in the flask 10.

The cap 16 is further adapted to receive the end 17 a hollow pressure conduit 18, hereinafter referred to as the top conduit.

The insulated base 19 of the flask 10 serves to house a trap 20 that is connected to the end 21 of a hollow pressure conduit 22, hereinafter referred to as the bottom conduit. The base 19 may also serve to house means (not shown) whereby the liquid may be withdrawn from the flask 10.

In accordance with the present invention the ends 23 and 24 of the top and bottom conduits 18 and 22, respectively, are connected to a gauge 25 having an indicator arm 26 adapted to move over a scale 27 calibrated to indicate the quantity of liquid 13 in the flask 10.

As hereinbefore set forth, when the liquid 13 enters the bottom conduit 22 from the trap 20, it will vaporise almost instantaneously into a gas. Therefore, the bottom conduit 22 contains a column of gas under a pressure equal to the sum of the pressure of the gas in space 14 and the hydrostatic pressure of the liquid 13 in the flask 10. On the other hand, the top conduit 18 contains a column of gas under a pressure equal to the pressure of the gas within the space 14. It is apparent, therefore, that the top and bottom conduits 18 and 22, respectively, deliver a pressure differential to gauge 25 that is, in effect, the hydrostatic pressure or head of the quantity of liquid 13 within the flask 10. The gauge 25 is constructed, in a manner to be hereinafter more fully described, so as to convert this pressure differential delivered to it by the conduits 18 and 22 into a mechanical movement that moves the indicator 26 over scale 27 to indicate the quantity of liquid 13 in flask 10.

Referring now to Figs. 2 and 3 of the drawings wherein the details of the gauge 25 of the present invention are illustrated, 30 designates a casing to which is mounted by screws 31 and 31*a* a base plate 32 and a back plate 33.

Peripheral flanges 34 and 35 formed on the base and back plates 32 and 33, respectively, co-act to clampingly engage therebetween the edge portion of a flexible diaphragm 36. A pressure chamber 37 is thereby defined by the back plate 33, the flange 35 thereof and the diaphragm 36. An extension 38 formed on the back plate 33 is provided with a port 38*a* that is adapted to receive the threaded end 24 of the bottom conduit 22 thereby placing the chamber 37 in communication with the pressure within the bottom conduit 22.

The end of the casing 30 opposed to the back plate 33 is closed by a transparent panel or window 39 clampingly held in position between an internal shoulder 40 formed on the casing 30 and a retaining ring nut 41 that is received in the internally threaded portion

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42 of the casing 30. Suitable seals 43 are provided on the opposed edge portions of the panel 39. The base plate 32 has a central aperture 44 and it is apparent, therefore, that a second pressure chamber 45 defined by the casing 30, flange 34, panel 39 and diaphragm 36 is provided within the gauge 25. In order to place this second pressure chamber 45 in communication with the pressure in the top circuit 18, the casing 30 is provided with an internally threaded opening or port 46 adapted to receive the threaded end 23 of the top conduit 18.

Due to the foregoing arrangement, the diaphragm 36 is positioned within the gauge 25 and adapted to respond to a pressure differential existing between the pressures in chambers 37 and 45. However, while the pressures within the conduits 18 and 22 are of the order of 100 pounds per square inch the change in the pressure differential occasioned by the lowering of the liquid level in the flask 10 is relatively small. It is apparent, therefore, that should a relatively thick diaphragm be used in order to resist undesired deformation due to the high pressure within the casing 30, it would not respond promptly or accurately to small changes in the pressure differential. The present invention permits the use of a relatively thin and, therefore, accurate and quick responding diaphragm 36, by spring loading the thin diaphragm 36 with a flat helical spring 47. The spring 47 additionally tends to hold the diaphragm 36 in the zero or null position of the gauge 25.

To operatively associate the spring 47 with the diaphragm 36, the outer end of the spring 47 is secured by screws 48 to the base plate 32 and the inner end thereof is provided with an aperture 49. A stud 50 secured to and positioned centrally of the diaphragm 36 by the plates 51 and 52 and bolt 53, has an externally threaded cylindrical extension 54 adapted to be received in the aperture 49 of the spring 47. A nut 55 in engagement with the threaded extension 54 secures the inner end of the spring 47 to the stud 50. By virtue of the foregoing construction, a relatively thin diaphragm 36, capable of prompt and accurate response to a pressure differential between the pressure chambers 37 and 45 is provided within gauge 25. Moreover, the foregoing elements also co-operate with other elements, hereinafter to be set forth, to afford means whereby the gauge 25 may be calibrated and thus adapted for use with various types of flasks 10.

In order that the deflections or movements of the diaphragm 36 may be utilised to move indicator arm 26 over scale 27, a stud 56 is mounted on the stud 50 by having one end 57 thereof secured in an opening 58 in the stud 50. The opposed end of the stud 50 is bifurcated as at 59 and one end of a link 60 is pivotally secured between the bifurcations 59. The opposed end of the link 60 is pivotally joined to a rocker arm 61 that is adjustably mounted in a collar 62 secured to a rocker shaft 63. The rocker shaft 63 is supported for rotary movement by posts 64 and 65 that are fastened to the base plate 32 and carry adjustable spindles 66 and 67, respectively. A second collar 68 adjustably secured to the rocker shaft 63 has a thermo-responsive or bi-metallic rocker arm 69 rotatably mounted therein.

A mounting plate 70 mounted on and spaced from the base plate 32 by a plurality of posts 71, is provided with slot 73 to accommodate the rocker arm 69 during movements thereof.

A support plate 74 mounted on and spaced from the mounting plate 70 by the posts 75 has the dial or scale 27 secured thereto, and, in addition, thereto, co-operates with mounting plate 70 to support a shaft 77 for rotary movement. The shaft 77 is biassed by a clock spring 78 to the end that a rod 79 carried by a collar 80 secured to the shaft 77 is constantly urged into contact with the thermo-responsive arm 69. To transmit the rotary movement of the shaft 77 in response to the rotation thereof by the arm 69, or the spring 78, to the indicator arm 26, a gear sector 81 secured to the shaft 77 meshes with a pinion 82 carried by a shaft 83 that is rotatably supported in the mounting and supports plates 70 and 74, respectively, and to one end of which is secured the indicator arm 26.

Thus, due to the construction and arrangement of the elements hereinbefore set forth, a deflection or movement of the diaphragm 36 in response to a change in the pressure differential existing between the pressure chambers 37 and 45, respectively, will act through studs 50 and 56, link 60 and arm 61 to rotate the rocker shaft 63 and the thermo-responsive arm 69 secured thereto. Since the arm 69 and rod 79 are constantly kept in contact with each other by the clock spring 78, the shaft 77 will be rotated either by the arm 69 pressing against and sliding along the rod 79, or by the rod 79 following the arm 69 due to the biassing effect of the spring 78 on the shaft 77. Through gear sector 81 and pinion 82, the shaft 83 is rotated to move indicator 26 over scale 27.

Moreover, due to the foregoing arrangement, the indicator 26 may be adjusted to move through any desired angle over the dial 27 in response to the deflection of the diaphragm 36, or the arm 26 may be adjusted to assume a given position relative to the dial 27 with respect to a given deflection of the diaphragm 36. The rocker arm 61 is adjustably mounted in its co-acting collar 62, therefore, if the length of arm 61 is increased, the rocker shaft 63 will rotate

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through a relatively small angle in response to a given deflection of the diaphragm 36 and consequently the indicator arm 26 will also move through a relatively small angle relative to the dial 27. Similarly, the collar 68 is adjustable on the rocker shaft 63 to the end that if the collar 68 is moved along the rocker shaft 63 to a point close to the collar 62, the thermo-responsive arm 69 will contact the rod 79 at a point further removed from the shaft 77, i.e., the pivot axis of the rod 79, and therefore, the indicator arm 26 will also move through a relatively smaller angle relative to the dial 27. The collar 68 and its co-acting arm 69 are also adapted to be rotated on the rocker shaft 63 to the end that the rod 79 may be moved to position the indicator arm 26 at a given point on the scale of the dial 27 with respect to a specific rotation of the rotor shaft 63 in response to a given deflection of the diaphragm 36. Thus, the mechanism operating the indicator arm 26 is adjustable to move the arm 26 through a desired angular displacement over the dial 27, or to adjust the arm 26 to a specific reference point or mark on the dial 27 whereby a specific deflection of the diaphragm 36 is indicated on the dial 27.

As hereinbefore set forth, the present invention contemplates means whereby temperature changes internally or externally of the gauge will not affect the accurate operation thereof. To that end, the thermo-responsive arm 69 comprises a bi-metallic rod that is rotatably mounted in the collar 68. Therefore, by rotating the arm 69 in the collar 68, the engagement and co-operation of the arm 69 and rod 79 may be adjusted in a manner well known to the art, to compensate for changes in temperature. The manner in which the foregoing adjustment is made is more fully set forth in Patent Specification No. 514,568.

To provide means whereby the gauge 25 may be calibrated to indicate the quantity of a liquid contained within the flask 10, the stud 50 has a central recess 84 formed therein in which is fixedly secured a spherical contact member 85. A resilient lever or leaf spring 86 is secured by one end 87 thereof to the base plate 32 by a screw 88, while the opposed end 89 of the leaf spring 86 is positioned centrally of the aperture 44 in the base plate 32, and bears upon the spherical contact member 85. It is apparent, therefore, that the deflection or movement of the diaphragm 36 in response to a pressure differential between pressure chambers 37 and 45 will be resisted or controlled by leaf spring 86. To alter or vary the effective length of the leaf spring 86 acting through the contact member 85 and stud 50 upon the diaphragm 36, and to thereby vary the resistance of the leaf-spring 86 to movements of diaphragm 36, calibrating screws 91, 92, 93 and 94 are threaded through the mounting plate 70 and are positioned, and adjustable, to contact the leaf spring 86 at spaced intervals along the length thereof. Thus, by adjusting the calibrating screws 91, 92, 93 and 94 so that they are in graduated relationship to the leaf spring 86, i.e., in adjusted position the screw 91 is closest to the leaf spring 86, the screw 92 slightly further removed than the screw 91, the screw 93 slightly further removed than the screw 92, etc., the leaf spring 86 as it is moved in response to the deflection of the diaphragm 36 will successively contact the ends of the screws 91 to 94, inclusive. Each screw in turn, will, therefore, form the fulcrum about which the leaf spring 86 bends under the force resulting from the deflection of the diaphragm 36. Since the effective length of the leaf spring 86 is, therefore, reduced as it successively contacts the screws 91 to 94, inclusive, it is apparent that the leaf spring 86 will successively exert a greater resistance to the movement of the diaphragm 36.

To calibrate the gauge 25 and thereby adapt it to indicate the quantity of a specific type of volatile liquid contained within a flask 10 having a particular internal conformation as, for example, a flask having a spherical internal form, the volumetric capacity of the flask 10 is determined by well known mathematical formulae. A curve, such as is shown in Fig. 4, is developed to indicate the ratio between the hydrostatic pressure of the liquid to be contained in flask 10 expressed in terms of inches of water pressure (the abscissa) and quantities of the liquid contained within the flask 10 expressed in terms of volume, e.g., liters (the ordinate). Thus, the curve will indicate the full range of hydrostatic pressures resulting from filling or emptying the flask 10 with that specific type of volatile liquid by a convenient scale.

The casing 30 is removed from the base plate 32 and back plate 33 but the latter elements are held in operative relationship by the screws 31*a* in order to maintain the pressure chamber 37. The dial 27 is marked by a convenient scale to indicate the volumetric capacity of the flask 10. As shown in Fig. 1, the dial 27 is provided with a scale extending over 180° and indicating quantities ranging from zero to ten liters.

A source of pressure is connected to the port 38*a* and the diaphragm 36 exposed to a pressure from this source that is equal to the hydrostatic pressure of a given amount or volume of the liquid to be contained in the flask 10 as determined from the curve previously described. For example, the pressure applied to the diaphragm 36 may be equal to the hydrostatic pressure of 2 liters of the liquid to be contained in the flask 10.

The position of the indicator arm 26 rela-

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tive to the mark on the dial 27 indicating this volume of liquid is noted, and the mechanism operating the indicator arm 36 is adjusted as hereinbefore set forth to move the indicator arm 26 to a position where it registers an amount slightly in excess of 2 liters. The calibrating screw 91 is then brought into contact with the lever 86 and rotated until the indicator arm 26 is brought into agreement with the mark on the dial 27 indicating 2 liters.

The pressure being applied to the diaphragm 36 is then increased until it is equal to the hydrostatic pressure of a second given amount of the liquid as indicated on the curve and dial 27. For example, the pressure is increased to represent the hydrostatic pressure of 4 liters of the liquid. The position of the indicator arm 26 is noted, and if the mechanism operating the indicator arm 26 has been properly adjusted as aforesaid, the indicator arm 26 should indicate a quantity slightly in excess of 4 liters. The screw 92 is then adjusted to bring the indicator arm 26 into agreement with the mark designating 4 liters on the dial 27.

The foregoing steps are repeated until the gauge 25 has been calibrated for the full capacity of flask 10, i.e., 10 liters. It will, of course, be appreciated that any suitable number of calibrating screws 91-94, less or greater than the four shown, may be provided for calibrating an instrument designed for use with a liquid container of any given capacity. The number of screws used is not determined by this capacity, but rather by the fineness of calibrating adjustment desired.

When the gauge 25 has been calibrated, the casing 30 is re-positioned on and secured to the base and back plates 32 and 33.

Having thus described the detail construction and co-operation of the elements of the instant invention, it is apparent that by connecting the top conduit 18 to the port of the casing 30, the pressure in the flask 10 above the level of the liquid 13 will be delivered to the pressure chamber 45 where it will act upon the side of the diaphragm 36 forming one wall of the chamber 45. By connecting the bottom conduit to the port 38*a* in the back plate 33, a pressure equal to the sum of the pressure above the liquid level in flask 10 and the hydrostatic pressure of the liquid 13 within the flask 10 will be delivered to the pressure chamber 37 where it will act upon the side of the diaphragm 36 forming one wall of the chamber 37. It is apparent, therefore, that the diaphragm 36 is exposed to and will be actuated in response to the pressure differential existing between the chambers 37 and 45. The actuation or deflection of the diaphragm 36 in response to the pressure differential will operate the mechanism previously set forth to move the indicator arm 26 relative to the scale 27 to thereby indicate the quantity of liquid 13 in the flask 10.

What we claim is:—

1. A differential pressure-gauge, which comprises a diaphragm mounted in a sealed casing connectable on opposite sides of the diaphragm to sources of different pressure, indicating means in said casing including a dial and an indicator movable with respect to the dial, a mechanical connection from the diaphragm to the indicator to move the latter on deflection of the diaphragm in response to variations in said pressure difference, spring means tending to support the diaphragm in a null position relatively to the casing, and further spring means biassing the diaphragm in one direction only towards its said null position.

2. A liquid contents gauge adapted for use with a vessel containing a volatile liquid and having pressure conduits for sensing a pressure differential resulting from the quantity of liquid in the vessel, which gauge comprises a diaphragm mounted in a sealed casing connectable on opposite sides of the diaphragm to said respective conduits, indicating means in said casing including a dial calibrated to indicate the quantity of liquid in the vessel and an indicator movable with respect to the dial, a mechanical connection from the diaphragm to the indicator to move the latter on deflection of the diaphragm in response to variations in said pressure differential, spring means tending to support the diaphragm in a null position relatively to the casing, and further spring means biassing the diaphragm in one direction only towards its said null position.

3. A gauge according to Claim 1 or 2, wherein said diaphragm supporting means comprises a coil spring having one end connected to the casing and its other end connected to one side of the diaphragm.

4. A gauge according to any preceding claim, wherein said biassing spring means is a leaf spring mounted in the casing and having one end acting on the diaphragm.

5. A gauge according to any preceding claim, which includes calibrating means for controlling the deflection of the diaphragm from its null position against the action of said biassing spring means in response to predetermined pressure differentials.

6. A gauge according to Claims 4 and 5, wherein said calibrating means comprise one or more movable adjusting elements, e.g., screws, mounted in the casing and adapted to engage the leaf spring to vary the effective length of the latter acting on the diaphragm and thus control the responsiveness of the diaphragm to the pressure differential.

7. A gauge according to Claims 4 and 5, wherein said leaf spring has its free

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end acting on a stud projecting from the diaphragm, and said adjusting elements or screws serve to vary the effective length of the leaf spring acting on the stud.

8. A gauge according to any preceding claim, wherein said mechanical connection is adjustable for adjusting the indicator to assume a given position relative to the dial in response to a diaphragm deflection caused by a given pressure differential.

9. A gauge according to any preceding claim, wherein the dial is calibrated in volume contents of the vessel.

10. A gauge, and particularly a liquid contents gauge substantially as described in the specification and as illustrated in the accompanying drawings.

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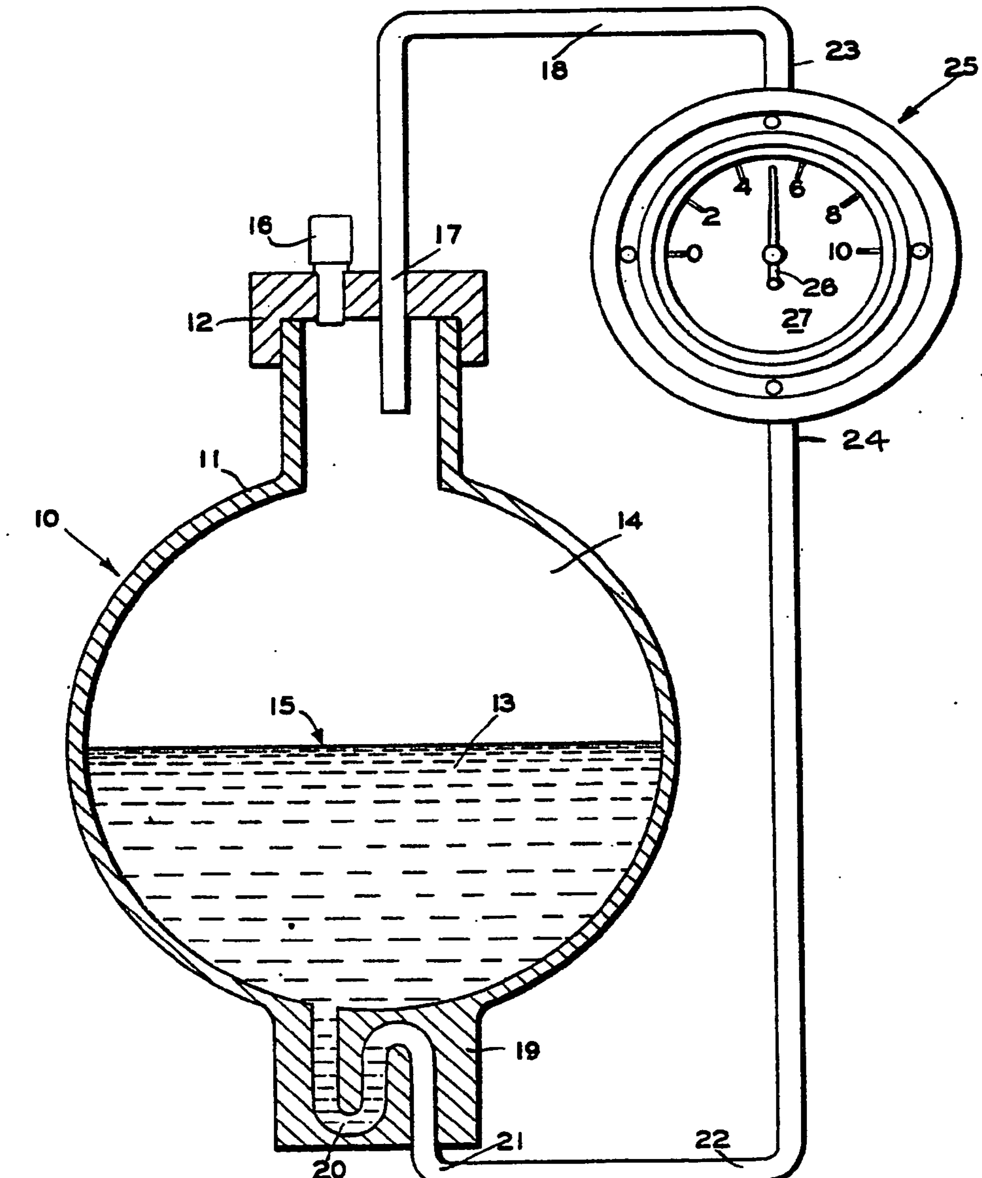
FIG.1



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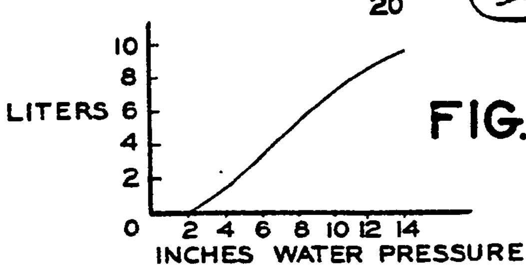

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INCHES WATER PRESSURE

FIG. 4

723,541 COMPLETE SPECIFICATION
2 SHEETS

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SHEETS 1 & 2

FIG. 2

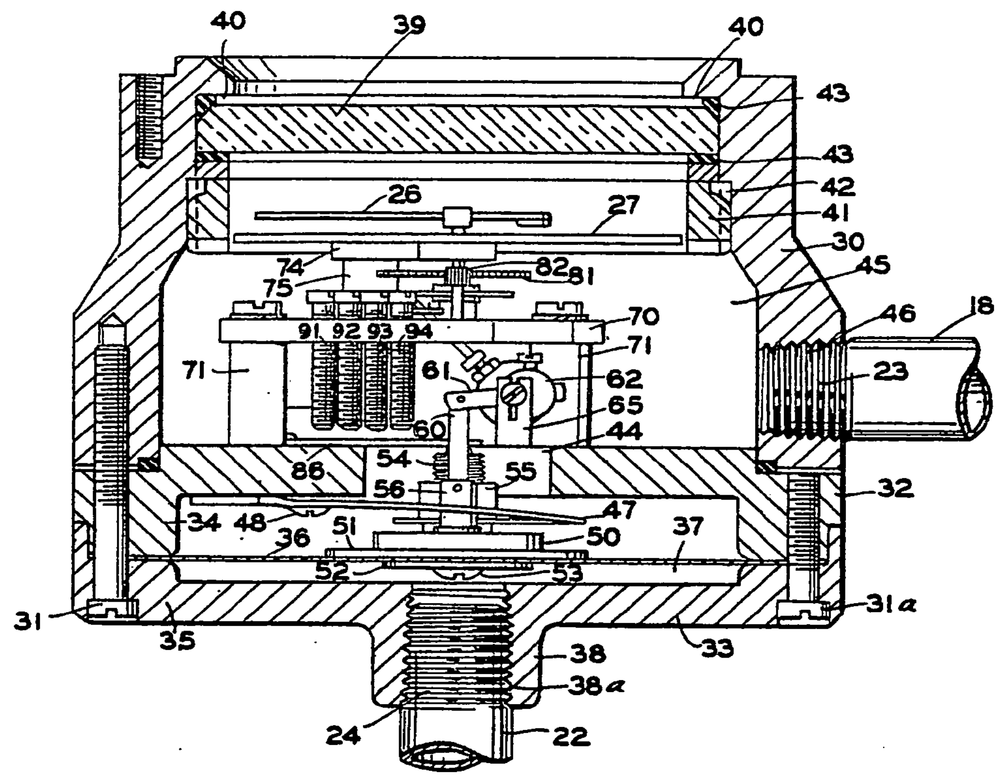
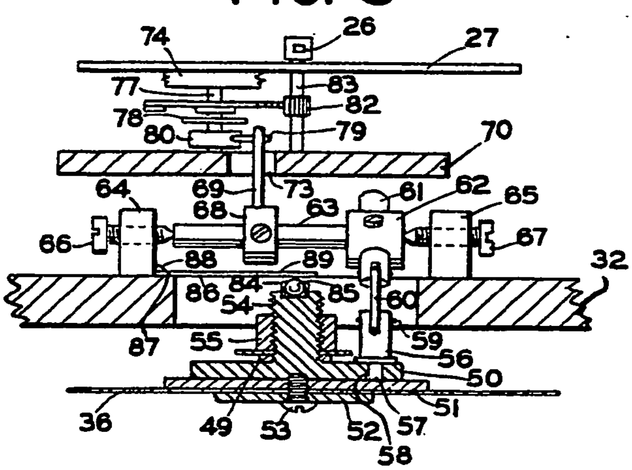


FIG. 3



723,541 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

FIG.1

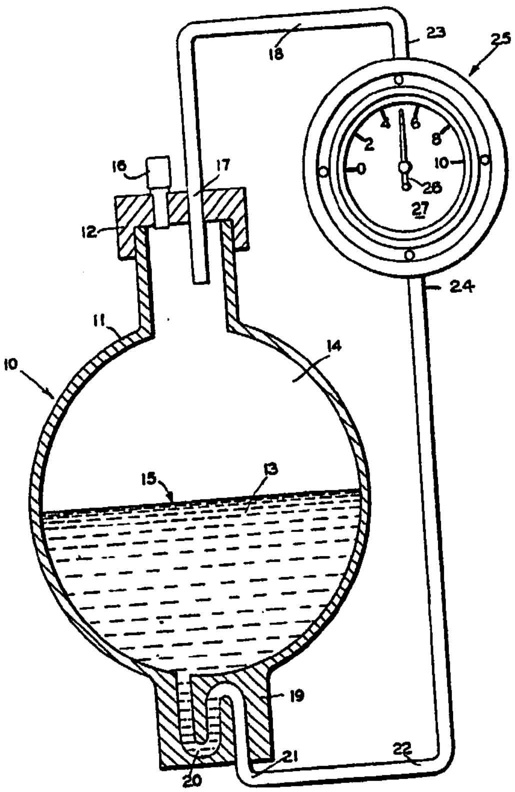


FIG. 4

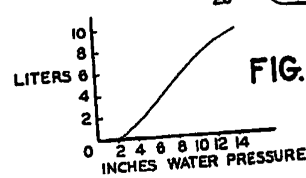


FIG. 2

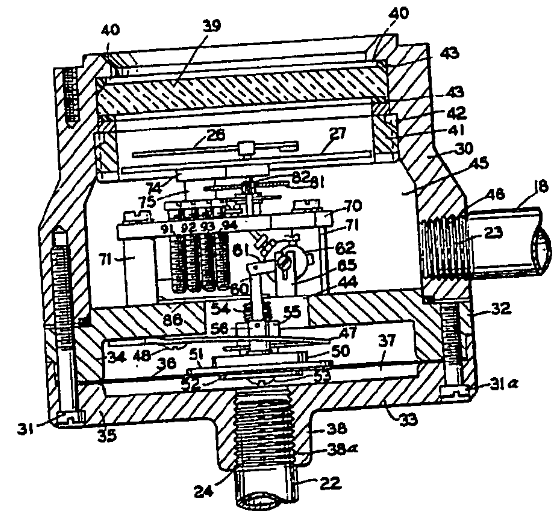
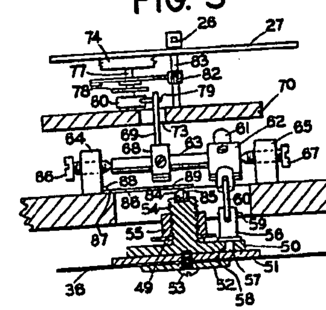


FIG. 3



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